Fertilizer Sources & Nitrogen Management

Jerome Pier, PhD
North Valley Division Agronomist
Crop Production Services
jerome.pier@cpsagu.com

“Two out of every five people on Earth today owe their lives to the higher crop outputs that fertilizer has made possible.”

– Bill Gates

Introduction

- Best management practices for reducing nitrate loading to groundwater must account for the properties of nitrogen fertilizers.
- Choosing the Right Source of nitrogen, in the context of Right Rate, Time and Place, will result in economically optimized and sustainable production.

Outline

- The Nitrogen Management Challenge
- Right Source Principles
- N Fertilizer Source Characteristics
- Conclusion

The Nitrogen Management Challenge

- N is nutrient most required by plants.
  - Plants respond visually to N applications.
  - Growers want their plants to be **GREEN**.
  - "Fertilizer" = Nitrogen fertilizer.
- Water and N are highly interactive.
  - Water drives transformations and losses.
  - N fertilizer has a direct cost **but,**
  - Water expenses are more indirect.

Economics & N Management

- Don’t apply enough N and water, lose yield.
  - For high value crops, risk is substantial.
  - Almonds @ $4.50 / lb * 100 lb = $450
- Over apply N and water and lose fertilizer.
  - N fertilizers at $0.50 - $0.75/lb N
  - N removal from 100 lb almonds = 6.8 lb N
  - 6.8 lb N * $0.75/lb N = $5.10
  - Return on Investment: > 80:1

Uncertainty of N Loss Calculations

- N Losses are based on mass balance.
  - Try to account for all inputs and outputs
  - But many unknowns and assumptions.
  - Currently, no simple method for measuring loss.
- N Removal is a f (yield).
  - Difficult to estimate prior to harvest.
  - High variability within a management block.

Scientific principles for Right Source

- Consider
  - Other 3R's: Rate, Time, and Place of application
  - soil physical and chemical properties
- Recognize
  - synergisms among nutrient elements and sources
  - blend compatibility
  - benefits and sensitivities to associated elements
- Supply nutrients in plant-available form

Adapted from IPNI 4R Plant Nutrition Manual Chapter 3

N Sources

- All N fertilizer starts as ammonia. (Haber process)

$$N_2 + 3\ H_2 \rightarrow 2NH_3$$

- Ammonia is pressurized and used directly, or converted to various solid and fluid fertilizers.
- Urea, ammonium and nitrate are most common.
- Each N Source behaves uniquely.

Source: Ammonium-N

- Anhydrous use decreasing
- Aqua (20-0-0) ammonium hydroxide solution
  - Still used in rice
- Most ammonia reacted with sulfuric, phosphoric or nitric to form fertilizer salts
- MAP, 10-34-0, ammonium sulfate, etc.
- All acidifying sources of N

AMS >> MAP > 10-34-0 = UAN

Ammonium-N

- Root uptake by diffusion, not mass flow.
- Active uptake but fewer net calories.
- Roots export one H+ for each NH4+ taken up.
- Microbially mediated oxidation of ammonium, nitrification, generates acidity.
- Seedlings and grasses utilize ammonium-N.
- Rice and blueberries need all ammoniacal-N

Source: Urea-N

- Two-step production reaction

$$2NH_3 + CO_2 \leftrightarrows (NH_2)_2CO + H_2O$$

- Most concentrated (46%) dry form of N.
- Half of most concentrated liquid, UAN-32.
- 150 Mtons consumed worldwide each year.
- 57.4% of total N fertilizer produced.
- Safe to handle
- Urea is compatible with phosphoric acid where UAN is not.

Urea

- Must be incorporated or watered in.
- Should not be applied with seed.
- Non-polar prior to hydrolysis.
- Hydrolysis takes place in 24-48 hours forming cationic ammonium ions.
- Volatilization losses
  - Most losses surface applied on warm, dry, sandy, high pH soil with a strong surface wind.

Urea and Fertigation

- Urea moves with water, similar to nitrate.
- When fertigating, apply ALL urea sources toward the end of long irrigation sets.
- Acidifier: 0.84 lb $CaCO_3$ / lb urea
- Following hydrolysis, ammonium cations are retained.

Reducing Urea Losses

- Urea stabilizers interfere with urease.
- Slow release polymerizes ureas.
- Controlled release coated with polyurethane.
- Products limit soil solution N concentration.
- Added cost per unit N but reduced losses.
- The right source may allow planting in sensitive areas.

Source: Nitrate-N

- Produced by reacting ammonium with oxygen using a catalyst, then reacting with water to form nitric acid, HNO_3
- Nitric acid reacted with potassium hydroxide, calcium carbonate, or ammonia gas to form potassium, calcium and ammonium nitrates
- CaNO3 mixed with ammonium nitrate to make CAN-17
- Urea mixed with ammonium nitrate -> UAN

Nitrate-N

- Immediately available for plant uptake.
- Ideal for cool soils.
- Moves by mass flow; passive uptake.
- Moves with the wetting front.
  - Must be applied toward the end of irrigation set
- Tends to slightly raise soil pH.
- Lower analysis and higher cost per unit N
- Larger caloric requirement for assimilation

Mixed N Sources

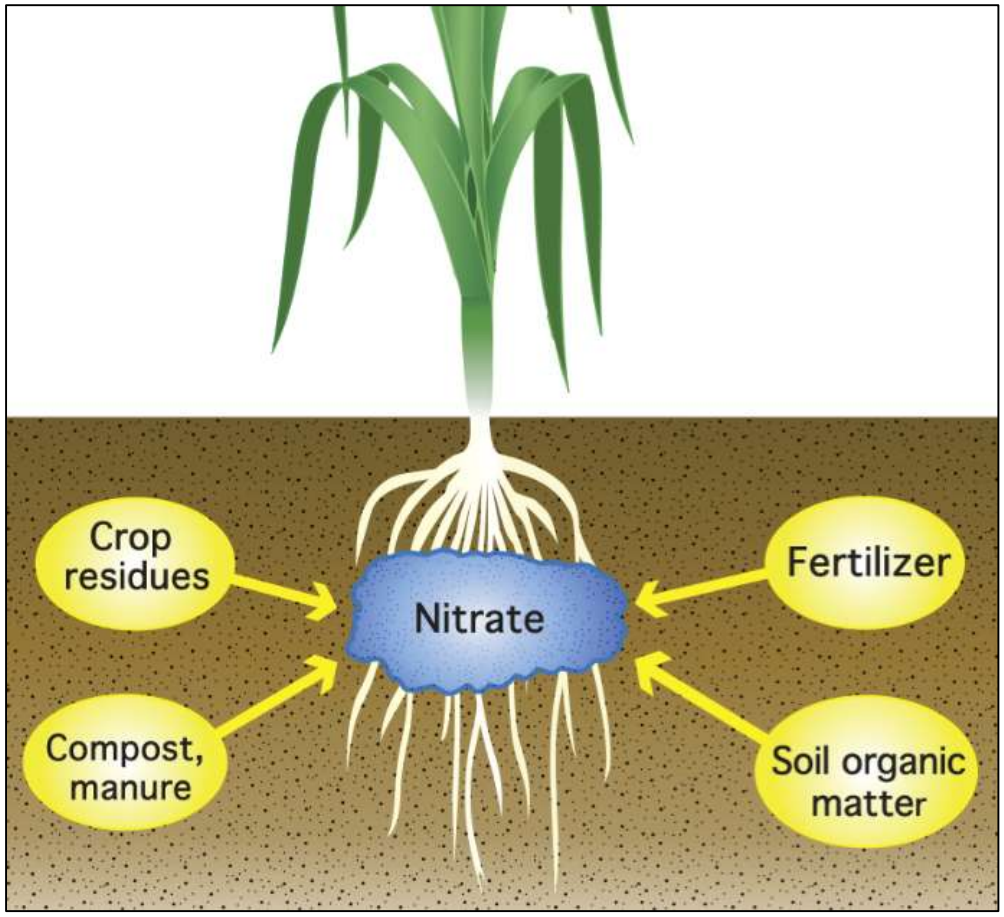
- Urea ammonium nitrate: extended feeding
  - Nitrate immediately available, followed by nitrified ammonium and urea
  - Urea and nitrate are BOTH mobile
  - An acidifier
- CAN-17
  - Maintains pH balance due to NO3:NH4 ratio
  - Soluble calcium flocculates soil, cation exchange

Source: Organic-N

- Mineralization must occur before organic-N is available for plant uptake.
- Mineralization rates depend on soil temperature, moisture, aeration, etc.
- Hard to align crop uptake with N release
- Organic sources are low analysis and bulky.
- Cost depends more on trucking.
- Well managed, improve soil quality & health.

Organic-N

- N source is not important once in the plant.
- Roots take up inorganic nutrients
- Nitrate is the same from fertilizer, manure, soil OM or <u>water.</u>



Making the Right Choice

- Ammonium sources
  - Soils with free lime and elevated pH
  - Acid loving and flooded crops
  - Warm, moist soil speeds nitrification
- Nitrate sources
  - Cool weather, drip vegetables
  - Low pH and low buffering capacity
- Blends, stabilizers, CRF, slow release

Making the Right Choice

- Organic sources
  - Organic certified production
  - Improve soil water and nutrient retention, tilth
  - Product is available locally and is of known quality
- Stabilizers, CRF, Slow release, etc.
  - Turf and ornamental
  - Environmentally sensitive situations
  - Potential for high losses

Conclusion

- Choosing the right source of N fertilizer depends on
  - the value of the crop,
  - price of the fertilizer,
  - soil physical and chemical properties,
  - method and timing of application,
  - environmental factors
- Don’t select fertilizer on price alone!